POLITECNICO DI TORINO

Honors thesis

DEGREE IN SUSTAINABILITY DESIGN

Abstract

Analysis of real energy consumptions by means of energy signature: the case of Valentino Castle.

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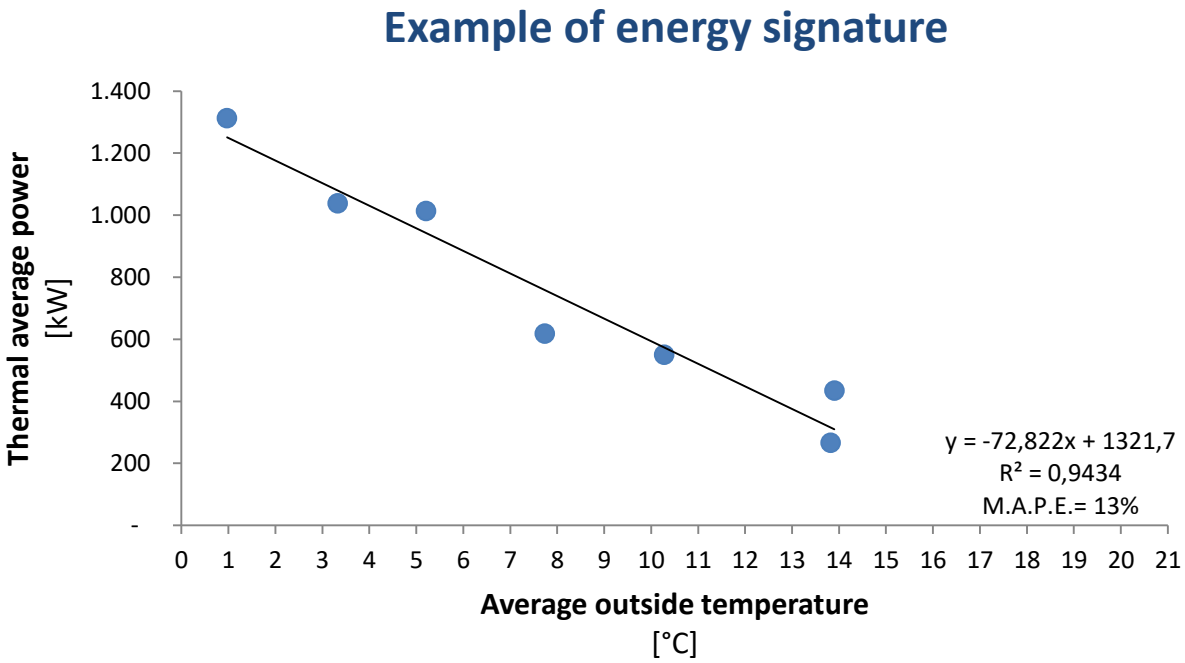
July 2016

The aim of this thesis is the application of the energy signature method to provide preliminary energy diagnosis of the Valentino Castle (Politecnico di Torino), based on the real thermal energy consumption data collected during winter seasons.
The energy signature is a powerful simplified tool for the assessment of building energy performance through a regression approach. Plotting the average thermal power versus average outdoor temperature the energy signature model is obtained using simple linear regression.
The energy signature can potentially provide useful information about the actual system management of a building eventually highlighting anomalous energy consumptions and the oversizing of the heating system. At the same time, the energy signature method allows to assess the effectiveness of retrofitting actions implemented along the monitored period.
In the analysed case study, the energy signatures for 15 heating seasons (from 2001 to 2015) are calculated starting from monthly methane gas bills and weather data gathered by Politecnico di Torino.
After the data collection it is possible to build the energy signature using the monthly average outside temperature and the monthly average power supplied to the building (Average power is obtained by dividing the energy use by the duration of the time interval between successive records assuming 14 operating hours per day).



The Figure 1 shows an example of energy signature and in particular the strong linear relationship between consumption and temperature also for analysis at monthly scale.
Specifically, the line slope reflects the sensitivity of the building to changes in external temperature and can be compared with building heat transfer coefficient H_{tot} [W/K].

In order to evaluate the regression quality, the coefficient of determination R^2 and the Mean Absolute Percentage Error (MAPE) index are calculated.

The 15 energy signatures computed was analysed in order to identify representative regression lines for the entire monitored time period. In particular were identified three reference energy signatures, each of them were computed by analysing the energy consumption data of all the seasons between two consecutive retrofitting actions. In this way, the reference energy signature is computed starting from a higher number of samples than just one heating season, for the sake of robustness of the model mitigating the effect of outliers.
The three standard energy signatures were compared in order to highlight the differences between them and assess the energy saving related to the refurbishment actions. The results of this comparison show no relevant improvements between the first and second energy signatures, when retrofitting actions have been conducted only on the building envelope (e.g. replacement of windows in some parts of the building).
Instead, a sensible improvement between the second and third period was detect, when the heating generator was substitute.
Moreover, through this analysis the interaction of the user with the heating system (e.g. setting of indoor temperature) was recognized as the most probable cause of high energy consumption during some heating season.
Indeed, the energy signature analysis represents a powerful tool both for improve the heating system management both for assess the impact of a refurbishment action.
Finally, a simplified physical model of the castle was developed in order to support decision on which retrofitting measure will be the most suitable to put in practice in Valentino Castle.

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